13

differential map is created. Such a difference may be mistaken by the DSP **248** for a relevant signal such as a finger signal.

[0242] For simplicity of explanation the opposite case is taken: a user's finger may be placed on the display panel during the actual mapping process. The finger inputs a signal (F1s) to a sensor conductor **242** as before. The sensor conductor also receives a steady noise signal (D1s) from the display panel. Another sensor conductor **240** receives a steady noise signal (D2s) from the display panel. These two sensor conductors are connected to the same diff amplifier **244**. The differential received and amplified by the diff amplifier equals {(D1s)+(F1s)}−(D2s). Some time after the mapping process is over, the finger is removed. The new differential amplified is now equal to: (D1s)−(D2s). The DSP subtracts the value stored in the differential map from the new value. The result equals: {(D1s)−(D2s)}−[{(D1s)+(F1s)}−(D2s)]=−(F1s). Realistically, the (F1s) value represent the magnitude, and the (−) sign represents the phase. This result is exactly the differentiation expected when a finger is placed on the second sensor conductor and assuming that a finger had not been placed on the first sensor conductor during the mapping process. The DSP responds as if a finger was detected, although no finger is actually placed on the display panel.

[0243] One embodiment of the present invention utilizes the embodiment described above where the mapping process is performed once during the manufacturing process. As the expected signaling objects creating the detection of signaling objects through the mapping process problem explained above are mostly a user's finger, fingers, palm, fist etc; and as the manufacturing environment is one where no user is present, the problem is solved.

[0244] The disadvantage of the above approach is the reliability of a single mapping process. Due to system's mobility, temperature changes, mechanical changes, etc, the differentiation between the signals produced by the display panel on any two sensor conductors connected by a differential amplifier may change over time, rendering previously recorded differential map values obsolete. A strictly controlled manufacturing process may solve the disadvantage by ensuring that no such changes occur, but such a process increases costs. On the other hand it is reasonable to believe that extreme changes in environmental conditions will not occur during a single operation cycle of the system (i.e. from turning on the computer until shutting it down). Hence, initializing the mapping process upon system initialization should suffice in most cases.

[0245] One embodiment of the present invention comprises performing mapping during each system initialization. During the initialization the user may be warned, either by a caption on the display panel or in any other manner, not to touch the display panel. As the expected signaling objects are typically the user's finger, fingers, palm, fist etc, this warning solves the problem. In a variation, not only is mapping carried out at each initialization but again at every time there is a doubt regarding the validity of the differential map. Methods designated to identify such doubts are described hereinbelow.

[0246] Methods of Identifying Doubts in the Validity of the Differential Map

[0247] In one preferred embodiment of the present invention, simultaneous identification of more than a single finger's pattern is utilized in order to identify a doubt in the validity of the differential map.

[0248] Thus, whenever the DSP simultaneously detects more then a single finger's signal pattern, a doubt in the validity of the differential map is inferred, and the DSP launches a new mapping process.

[0249] Reference is now made to **FIG. 18** with which an example of such a procedure is described. Two groups of three lines are shown, a first group labeled Fs and a second group labeled PFs. Each line represents two sensor conductors connected to **10** the same differential amplifier. The lines represent sensor conductor axial signal detection, preferably after subtracting the steady noise from whatever source, such as the display panel steady noise, as explained above. The height of each line represents the signal's magnitude. (Fs) and (PFs) are finger signal patterns. If the user places a finger on the display panel during the mapping process, then a finger signal pattern (PFs) is detected only once the finger is removed, as explained above. Once the user actually places a finger, another finger signal pattern (Fs) is detected. Once two finger signal patters are detected on the same axis a doubt in the validity of the differential map occurs, and the DSP launches a new mapping sequence.

[0250] It is noted that the same method can be used to identify not only more then one finger but also one single object that is larger than a finger, such as a fist or a palm.

[0251] The detection of such an object's signal pattern immediately raises doubts regarding the validity of the differential map.

[0252] One disadvantage of the above described method of reinitializing in the face of a doubt is that it may enter an endless cycle of reinitializing. Thus, in the example explained in **FIG. 18**, the new mapping process is launched, but the finger that created signal pattern (Fs) in the first place is still in place on the display panel, damaging the validity of any reinitializing carried out at this point.

[0253] An additional disadvantage is that such a system may be used solely in systems capable of single finger detection. Once a system is designed to detect more than a single touch, then multiple touch is a totally legitimate input signal and cannot be taken as an indication that reinitializing is required.

[0254] In another preferred embodiment of the present invention the detector identifies doubts in the validity of the differential map by utilizing the signal's phase information. As explained above, the phase of a signal caused by a "pseudo" finger is opposite (180 degree) to the phase of a signal caused by a real finger placed in the same position. Therefore, in a preferred embodiment, the system identifies doubts by detecting contradictions between phase and position. However, since a differential amplifier has two inputs, negative and positive, a real finger located on the other input of the amplifier can lead to an opposite phase as well. Therefore, in order to avoid ambiguity, the system detects the position of the finger without using phase information.